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Collembola and Gamasina — bioindicators for soil compaction

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In compacted soils numbers of species and individuals of Collembola and Gamasina are reduced. The relation between the sum of individuals of certain species and the total number of individuals can be used as a bioindicator for soil compaction.

1. Introduction

Traffic with heavy machinery on agricultural land may lead to severe soil compaction. In this paper Collembola and Gamasina, two important taxa of the soil fauna, are used as bioindicators for soil compaction. This concept is based on data derived from a three year field study. According to Dunger (1983) small arthropods can give good information about soils.

2. Material and methods

The study site was a conventionally tilled parabrown soil of loess with 10% clay (Beckmann & Altemüller 1989). Each of the four sampled plots was 2 × 16 m in size. The plots were selectively loaded corresponding to conventional agricultural practice. The wheel loads per vegetation period were the following: plot 0: unloaded; plot 4: 8.1 t (3 drives); plot 5: 8.4 t (3 drives); and plot 7: 18.4 t (8 drives). Crop rotation consisted of sugar beet, winter wheat, and winter barley.

Eight samples, with a diameter of 4 cm each, were collected monthly to a depth of 15 cm from each plot from May 1988 to July 1990. Collembola and Gamasina were extracted using the method of Macfadyen (1961).

3. Results and discussion

Density and number of species of Collembola and Gamasina decrease with increasing soil compaction (Heisler 1990, 1991). These results correspond to observations of Aritajat et al. (1977a, b), who also observed a reduction of soil fauna, which was not permanent however. Kopeszki (1991) wrote, that Collembola are good bioindicators for soil conditions.

The most important Collembolan taxa typical for agricultural sites are *Onychiurus armatus* s.l. (Onychiuridae), *Mesaphorura krausbaueri* s.l. (Onychiuridae), and *Folsomia fimetaria* (Isotomidae). These three taxa decrease with increasing mechanical load (Fig. 1). This refers to each taxon as well as for the sum of all three taxa. *Onychiurus* has been previously described as being sensitive to soil compaction (Didden 1987). The proportion of these three taxa of total Collembola was 73% in the uncompacted plot 0, but only 30% on the wheel track (plot 7). On plots 4 and 5, compacted with medium loads, they comprise 50 to 60% of all Collembola (Table 1). All three taxa show negative correlation between individual numbers and wheel load (Table 2). The author suggests that if the proportion of euedaphic Collembolan taxa is:

- Less than 33%: compaction can be considered 'damage compaction',
- 33% to 66%: compaction is thought to be 'tolerable',
- 66% or more: soil is considered not compacted.

Thus for using Collembola as bioindicators for soil compaction as proposed, the total number of Collembola has to be determined as well as the total number of euedaphic ones.

Size and feeding preferences of Gamasina are crucial for the choice of species as bioindicators for soil compaction. The three species of predatory mites *Alliphis siculus* (Eviphididae), *Arctoseius cetratus* (Ascidae), and *Rhodacarellus silesiacus* (Rhodacaridae) feed on nematodes (Sadar & Murphy 1987, Binns 1974, Karg 1961a, b). They are small species with a body size less than 455 µm. All 3 species are pioneer species. The total individual number of these 3 species was well correlated with the degree of compaction (Table 2). Their numbers were reduced at high compaction (Fig. 1). The proportion of the three species of total Gamasina was about 80% on plot 0 (unloaded), about 90% on the plots with a medium loading (plot 4 & 5), and more than 95% on the extremly compacted plot 7.

The author suggests that if proportion of these small Gamasina is:

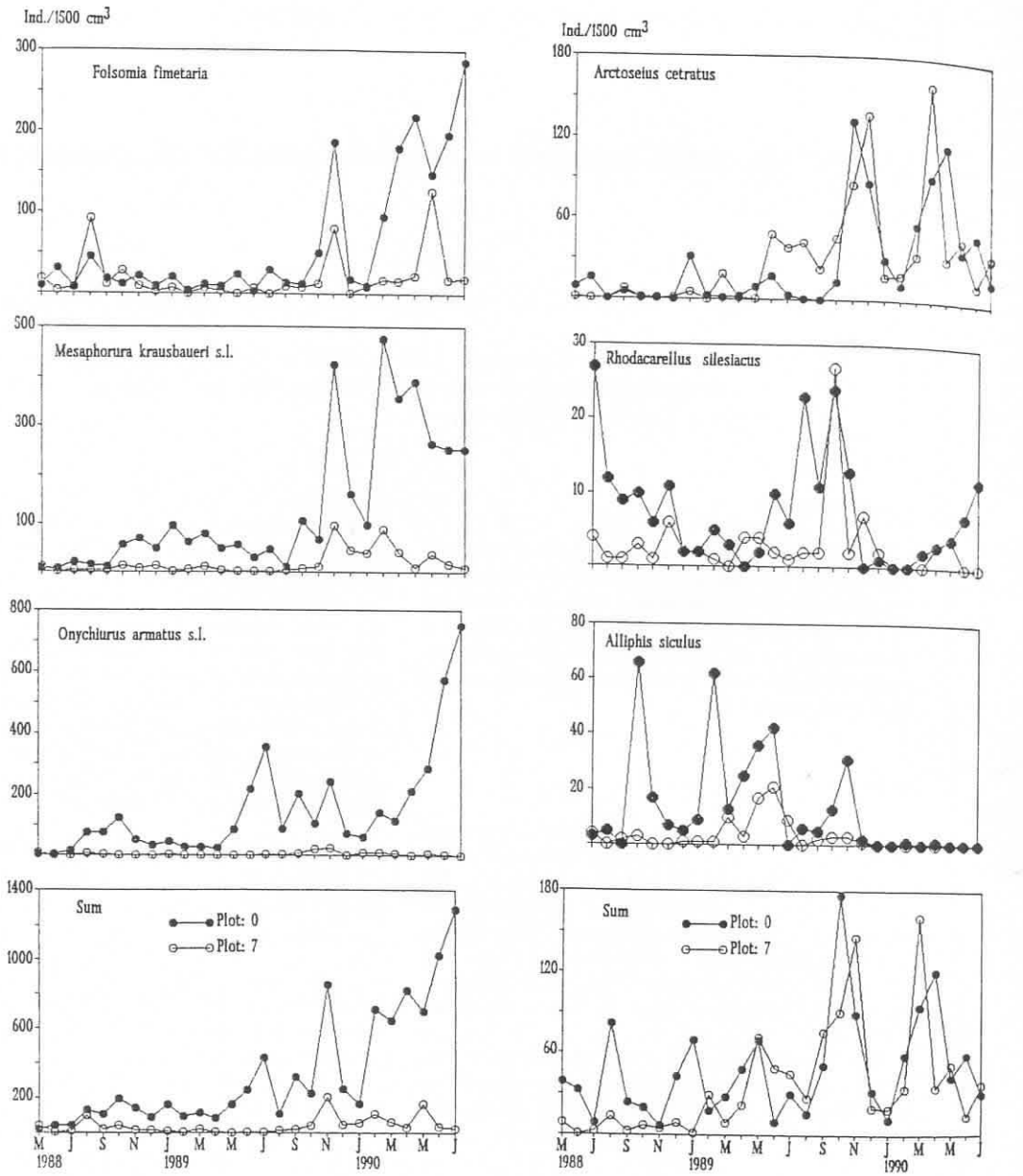

Fig. 1. Numbers of individuals of three euedaphic taxa of Collembola (left) and of three small species of Gamasina (right) in plot 0 (unloaded) and in plot 7 (wheel track) from May 1988 to July 1990.

— Less than 90%: soil can be considered uncompacted.
— 90% to 95%: compaction is thought to be 'tolarable'.
— More than 95%: compaction is considered 'damage compaction'.

According to Karg (1982) predatory mites are good bioindicators because of their position in the soil food webs together with bacteria, fungi, nematodes and springtails. These small Gamasina feeding on nematodes may profit from compaction, if their prey is promoted because of the higher proportion of water filled pores in compacted soil.

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Table 1. Proportion (%) of 3 euedaphic Collembola taxa of total Collembola numbers, and proportion of 3 small Gamasina species of total Gamasina numbers.

Plot:	0	4	5	7
Collembola	73.2	57.8	54.0	32.2
Gamasina	81.9	91.3	90.6	96.2

Table 2. Linear correlation between wheel load and total individual numbers of Collembola and Gamasina.

Species	Linear correlation	Coefficient (r)
Collembola		
Isotoma (Linné)	y = 1904.52 – 63.75 x	– 0.90
Folsomia quadrioculata s.l. (Tullberg)	y = 3100.81 – 159.15 x	– 0.94
Isotomiella minor s.l. (Schäffer)	y = 3147.50 – 202.04 x	– 0.86
Euedaphic species	y = 8152.83 – 424.94 x	– 0.94
Gamasina		
Veigaia cerva (Kramer)	y = 775.88 + 3.75 x	+ 0.46
Hypoaspis aculifer (Oudemans)	y = 289.14 – 13.94 x	– 0.86
Hypoaspis miles (Berlese)	y = 238.88 – 7.0 x	– 0.81
Euedaphic species	y = 1303.35 – 17.18 x	– 0.95

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